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Nature Based Solutions for Conservation and Management of Ullal Lake, Bangalore, Karnataka, India

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Abstract:- Attention to nature based solution in watershed conservation and management is increasing in the developing world as chemicals continue degrading agricultural land; garbage and urban sewage infrastructure are sediment clogged. The realization of significance of watersheds is fundamental for utilization that is sustainable where urban livelihoods recreation and economies are majorly dependent on the utilization of natural resources.Lake Ullal is characterized by surrounding population density that is high made up of urban population characterized by raw sewage disposal, garbage and flow of debris from construction. The catchment areas engage in agriculture characterized by use of pesticides and fertilizers that dissolve in the flowing water to the lake. These materials pose a serious threat to the watersheds.The high population density at the catchment has led to intensive agriculture that is characterized by pressure to yield more output to match the demand. There is a big gap between institutional and policy framework development at the high level and real implementation of proposals on the ground to combat soil erosion,land degradation and need to decrease the sediment load. The study mainly focused on the catchments of Ullal while assessing anthropogenic activities that have led to degradation of the lake. This provides an insight of nature based solution that can be adapted to conserve and manage the precious lake. The concept of Nature based Solution (NBS) provides adequate recommendation that can be adopted to salvage the lake for future generations.

Subject area: Geography

Keywords:- *Nature Based Solution, Watersheds, Catchment, Degradation and Conservation.*

I. INTRODUCTION

Lakes are essential for human habitat. It forms a habitat for rare birds, flora and fauna. They are useful for recharging of ground water. They form a vital part of fresh water ecosystem. In some instances they help in flood control. Human activities have influenced the natural processes of these lakes degrading them. Nature-based solutions are the interventions that utilize nature and natural functions of a healthy ecosystem to tackle a number of serious challenges today. These solutions aid to protect our environment as well as provide social and economic benefits. The nature offers great potential that has not been tapped for improving quality of the life of urban population and get solutions that are cost-effective to the challenges, such as the ever increasing temperatures that the urban heat island effect concept. The challenge is establishment of urban planning techniques and measures that enable people realize the abundant benefits and service that nature avails such as water, air, food, temperature regulation, recreational opportunities that also protect environment from unsustainable exploitation by man. Gleick (1998) states that , freshwater resources are renewable; therefore can be utilized in a manner that does not affect the sustainability of the resources in the long-term.

The freshwater resources in the world are under immense pressure. The population growth, accelerated economic activities and improved standard of living lead to increasing competition for the already existing freshwater resources. The ever rising population mounts pressure on hydrologic function of the watersheds. Consequently, dramatic changes are experienced in hydrologic and biotic components of the watersheds heralding unprecedented challenges manifested through land degradation.

The International Union for Conservation of Nature define NbS as vivid actions to protect , sustainably manage while restoring natural or modified ecosystems that yearns to address societal challenges adaptively and effectively, hence providing biodiversity and human well-being benefits.

Objectives of the study

1. To assess the anthropogenic activities in the lake and catchment for the past two decades.
2. To establish possible nature based solutions to conserve, manage and rejuvenate Ullal Lake.

II. MATERIALS AND METHOD

Research design

This study used primary and secondary data obtained from Karnataka meteorological department depicting the variation of precipitation, temperature, air pressure, wind and cloud cover. These elements were measured accurately at appropriate sites. Field study was carried out at the Ullal lake catchment where various anthropogenic activities were carried out. During field work oblique aerial photographs of the lake were taken. Geographical Information System(GIS) soft-wares were used to create maps. Arc view GIS 3.2

software was used for digitizing, editing, labeling, projecting and for analyzing the catchment area Digital elevation map of the lake was developed using the Erdas software. Interviews were conducted at sampled points of the rivers feeding lake Ullal to establish anthropogenic activities carried out and how they polluted the lake ultimately.

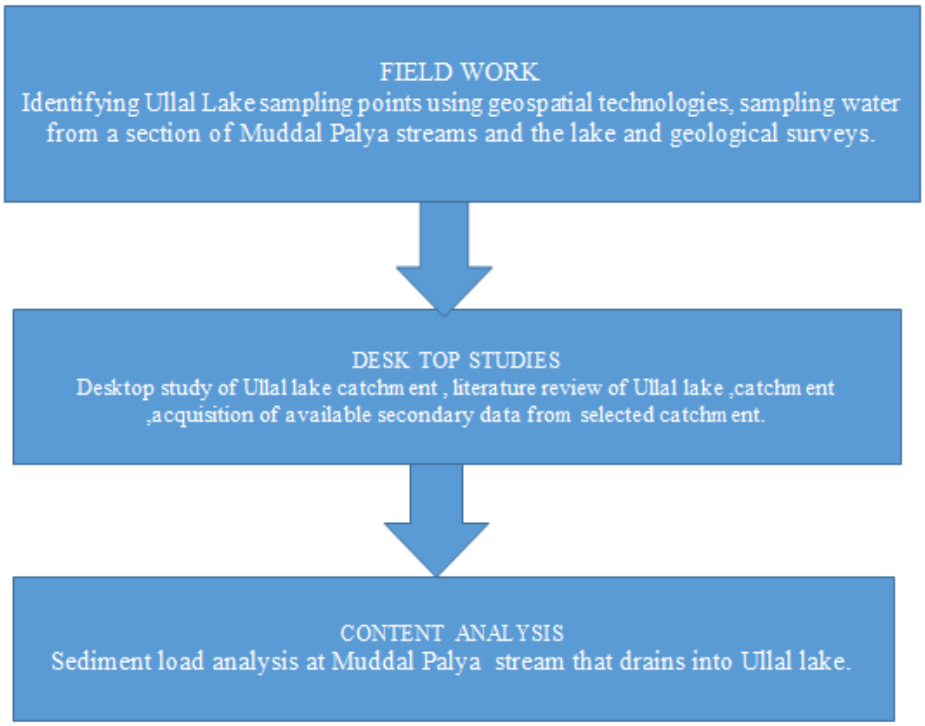

Fig 2.1 Research design

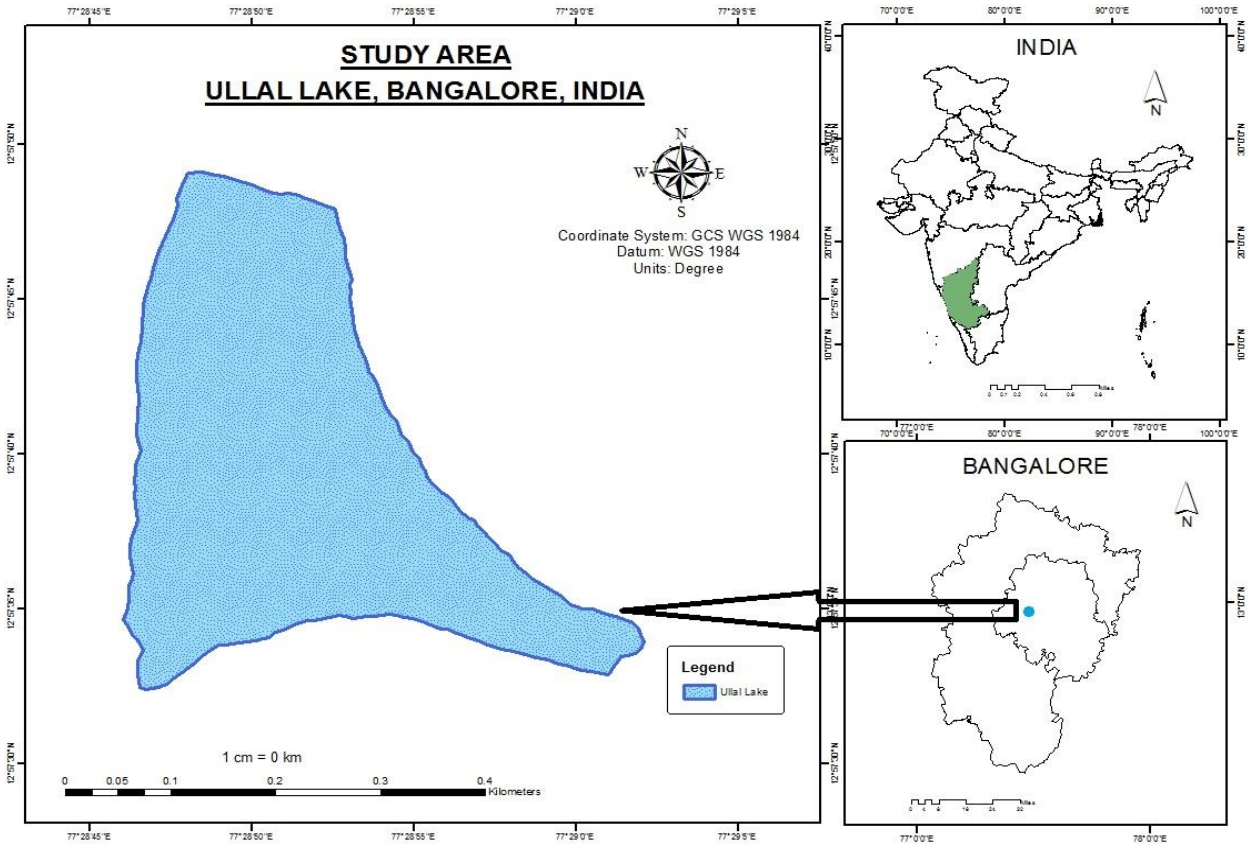

Fig 2.2 showing the map of Ullal lake the study area.

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Description of the study area: Ullal Lake and its catchment

The geographical context of the study area is Ullal Lake. Ullal Lake is situated in the village of Hullalu located in the South-Western part of the Bangalore city. It's situated between longitude 77^0 28' 48 '' E to 77^0 29' 04'' E longitude and latitude 12^0 57' 49'' N to 12^0 57'40'' N. Ullal lake is found in the Byramangala Lake series and Vrishabhavathi lake valley. Muddina Palya sorrounds it from the North, Mallathalli in the East,Mangana Halli in the South and Ullalu to the West. The main source of the lake is from North that is Muddina palya whereas the main outlet is from South-East that doubles up as the inlet to lake Hosakere.

Lake Ullal is somehow triangular in shape, extending about 11.03 hectares with a perimeter of approximately 1870 meters. The area of the catchment of the lake is approximately 325 hectares.Digitized lake boundary while using Toposheet number 57H/5 by ArcGIS shows the area of the lake to be 12.38 hectares. The area covered by the lake has significantly reduced from the previous12.38 ha to 11.03ha. Whereas the highest point of Ullal lake was 900 meters, the lowest was 840 meters above sea level. The Northern part forms the major source of the lake portraying a dendritic drainage pattern. Upcoming layouts characterize the catchment area. The activities include laying of roads, dumping of constructional debris and wastes ,constructional activities coupled with plantation. The rapid population growth, intensive agriculture and unsustainable practices of land management are the main threat to the source of Ullal lake.

Bangalore population density has increased 47% in a decade due to expanding opportunities and urban growth that is pulling quite a number of people from the whole nation. In 2011, population density was 4,378 people per square kilometer, an improvement from 2,985 in the previous decade. The population growth rate is 4.15% (Census 2011). Bangalore has experienced three times growth faster than the state and currently a home of 16% of Karnataka's population.

The temperature and rainfall of the study area

The table below summarizes the amount of rainfall and temperature received on average annually.

Temp/Rainfall	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
Avg,Temp ^{0}C	20.8	22.9	25.5	27.1	26.9	24.4	23.3	23.4	23.2	23.1	21.8	20.7
Mean Temp ^{0}C	14.3	15.7	18.3	20.6	20.7	19.4	19	19	18.5	18.5	16.8	15.1
Max Temp ^{0}C	27.4	30.1	32.8	33.7	33.1	29.4	27.7	27.8	28	27.8	26.8	26.3
Avg Temp ^{0}F	69.4	73.2	77.9	80.8	80.4	75.9	73.9	74.1	73.8	73.6	71.2	69.3
Min Temp ^{0}F	57.7	60.3	64.9	69.1	69.3	66.9	66.2	66.2	65.3	65.3	62.2	59.2
Max Temp ^{0}F	81.3	86.2	91.0	92.7	91.6	84.9	82.0	82.0	82.4	82.0	80.2	79.3
Rainfall mm	1	4	8	36	96	68	98	116	182	150	56	16

Table 3.1 showing the annual average of temperature and rainfall in India (Source India Meteorological Department - IMD)

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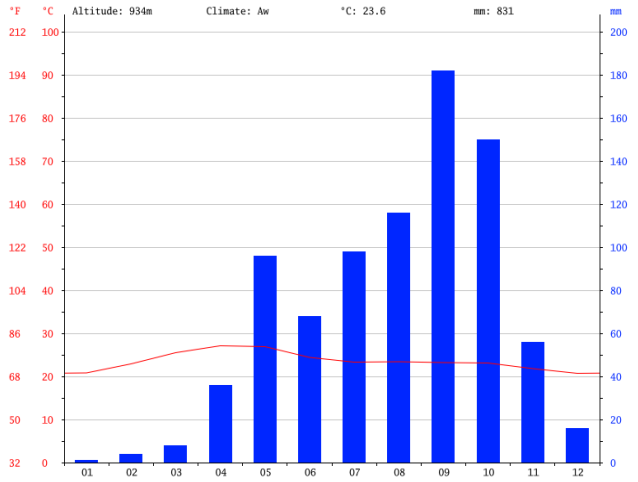

Fig 2.3 Rainfall graph

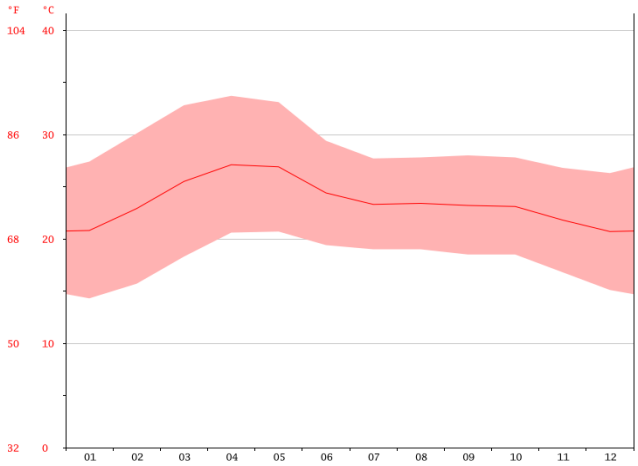

Fig 2.4 Temperature graph

The Relief and drainage of the Catchment area

The water flows from North to South-East. Some flows from South-West concordant to the natural gradient of land. This lake belongs to the series of lakes in the Vrishabhavathi valley. The area is located at the Deccan plateau region. The average altitude is 900 meters above sea level. The Northern part is higher than the southern making the source of the lake to originate from North part of the lake. The Lake has one main tributary providing water for the lake. The drainage pattern exhibited is dendritic drainage pattern.

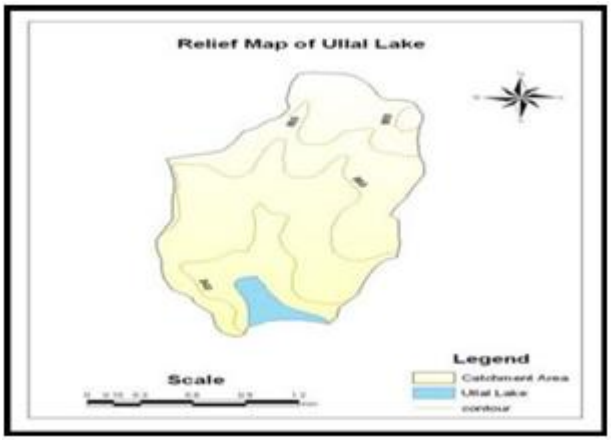

Figure 2.5 Relief Map of Ullal Lake

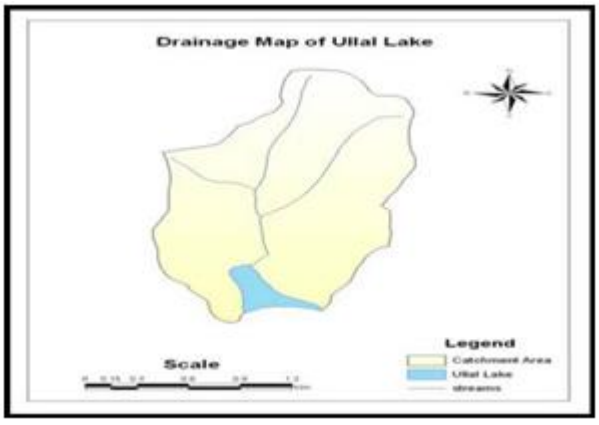

Figure 2.6 Drainage Pattern of Ullal Lake

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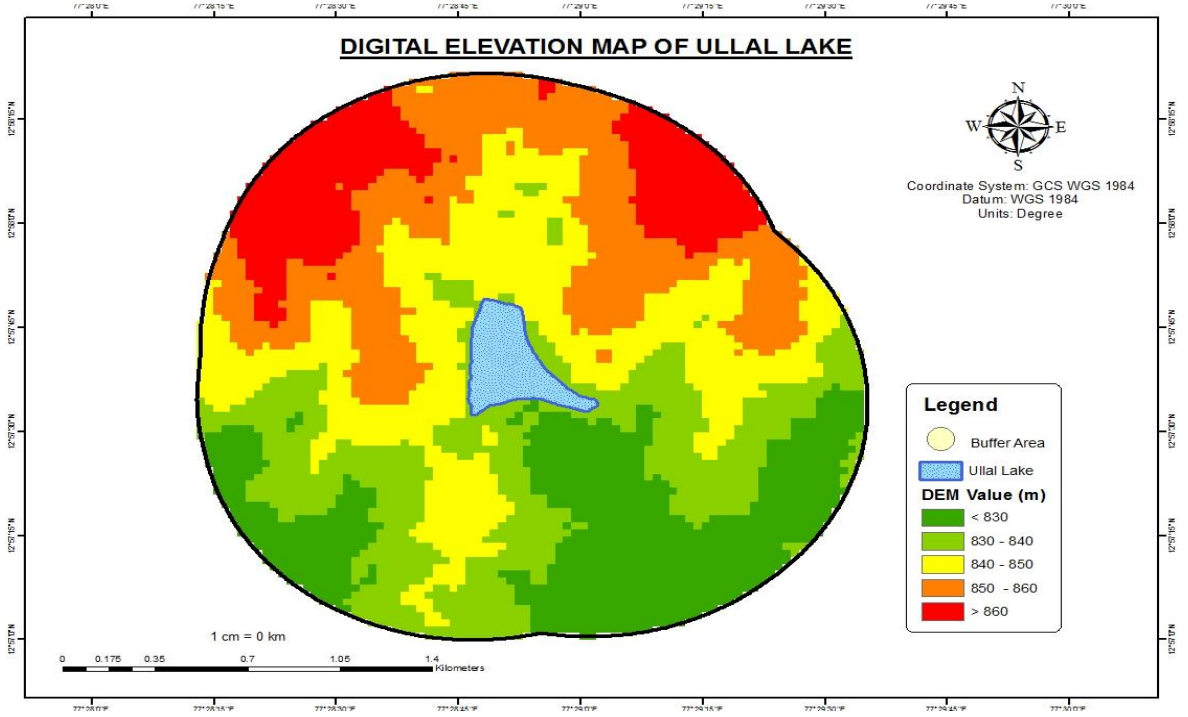

Figure 2.7 Digital Elevation Map (DEM) of Ullal lake and it's catchments

The population of the adjacent wards of the Ullal Lake

Sl. no.	Ward no.	Ward names	Population 2011	Area (sq.km)	Population density 2011 (person per sq.km)
1	8	Kodigahalli	47546	3.8	12369
2	44	Marappanapalya	40212	2	19785
3	124	Hosahalli	37347	0.9	42373
4	127	Mudalapalya	43729	1	45077
5	130	Ullalu	58199	8.7	6688
6	190	Mangammanapalya	65890	3.5	18956
7	86	Marathahalli	39768	3.1	12679

Table 2.1 Showing Bruhat Bengaluru Mahanagara Palike (BBMP) population of surrounding wards to Ullal Lake and the catchments (census 2011).

With a population of Bangalore metropolitan city projected to be between 10,456,000 and 12,339,000, an increase from 8.5 million in 2011 census records, Bangalore is a leading megacity, and the fifth most populated city in India. This ranks Bangalore at rank 18 mostly populated cities in the globe. Bangalore city was ranked the fastest growing metropolis in India following Delhi between the years 1991 and 2001, at a growth rate of 38% then. The rapid growth of industries, trade and commercialization remains a leading for rapid growth hence large scale urbanization. Education institutions too are more. The urbanization process has not spared the lake catchments. The sampled surrounding catchments have a population density on average of 20,000 persons per square kilometer which makes the population to be dense.

Primary Data Base

Karnataka Toposheet 57H/5 was selected where the study area lies. The toposheet was digitized and Ullal lake shape files were created. QGIS and ArcGIS software used in the process of creation of maps. Landsat images were downloaded from Google earth. Further Bhuvan portal was used to extract Land Use Land Cover Changes(LULC) changes and create a DEM.

Field observations

Direct observations as qualitative method of data collection was used to cover the physical environment and activities in the Ullal Lake catchments. A field visit was conducted to Ullal Lake and its major in fluent river. Muddal Palya was chosen because of its high population density. The field visit aimed at assessing land use activities such as the disposal of garbage and sewage was keenly observed besides the intensity of agricultural activities at the catchment.

Interviews

The interviews were done with the key informants to get information about the links , conservation practices, and the interaction of land degradation, land use implemented aimed to reduce land degradation and increased sediment load at the river catchments. One-to-one interviews, land degradation were done. Key informants at the lake were purposively chosen using on their own experience in water

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resources , environmental management and natural resources.

Secondary data collection

Relevant data to study the subject was collected from authentic publications, reports of Census (2011), documents, Bangalore Metropolitan Region Development Authority (Road network and built up area),Bangalore Bruhat Bengaluru Mahanagara Palike (BBMP), the forest department included sources of secondary data. Bangalore Meteorological department was instrumental in providing Rainfall and temperature data. The secondary sources were re-examined so as to supplement the view of the primary data.

III. RESULTS

The major causes of land degradation in Ullal lake

Cause	Number of respondents	Percentage
Raw sewage release	6	30
Garbage disposal	4	20
Agricultural & industrial wastes	4	20
Construction debris	3	15
Ganesh idols and puja materials	3	15
Total	**20**	**100**

Table 3.1 showing the major causes of degradation of Ullal Lake and its catchments

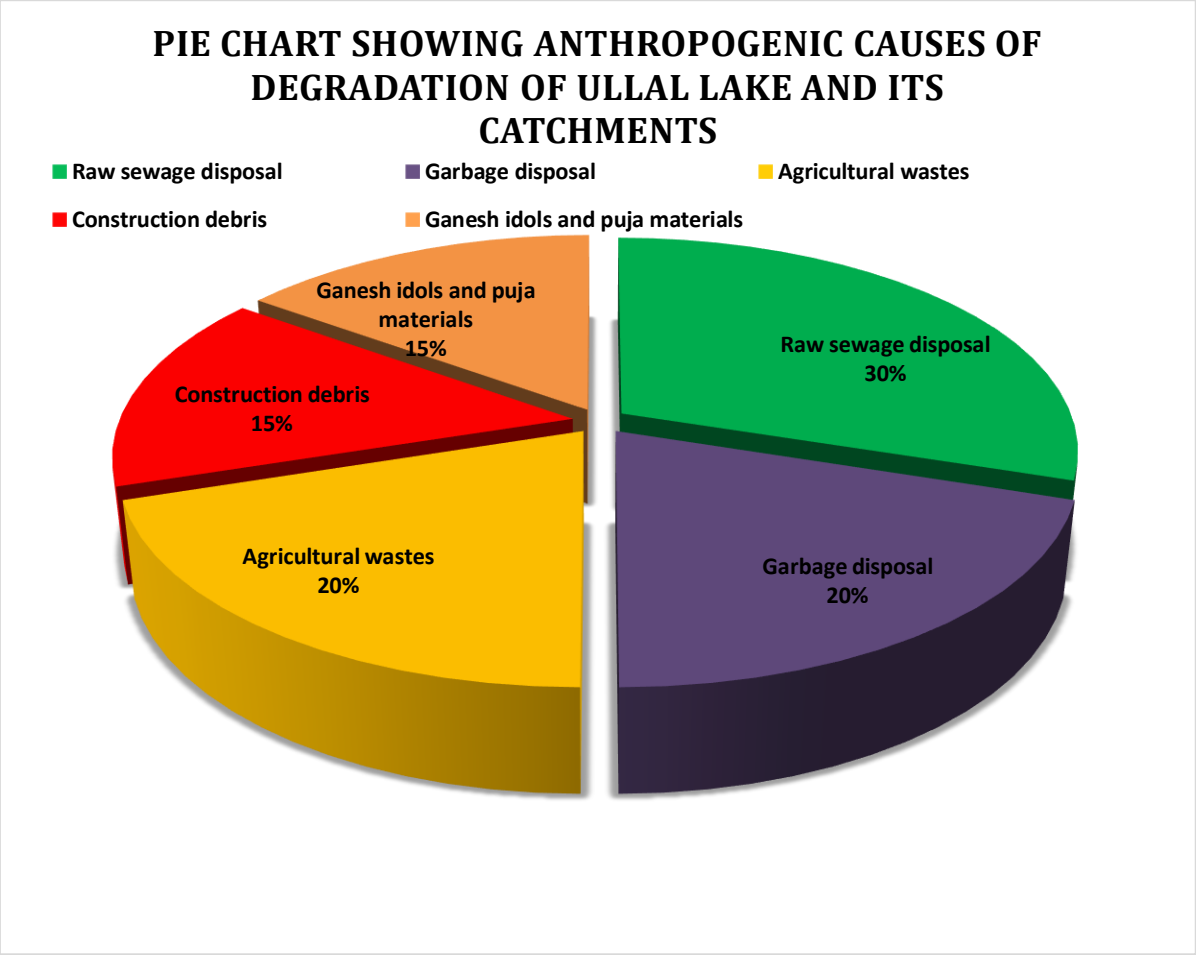

Fig 4.7 showing summary of anthropogenic causes of Ullal lake degradation

The landsat images below shows the land cover and land use changes from the years 2000,2009 and 2018, The images precisely shows how green area has been decreasing as built up area has been increasing temporal spatially.

Figure 3.1 showing lansat imageries of LULC temporal-spatially(Google earth)

IV. DISCUSSION

Anthropogenic activities leading to land degradation and Pollution in Ullal Lake catchments

From study of the lake, it is evident that human activities play a vital role in the outcome of the lake. The main human activities that have contributed to the pollution of the lake include release of raw sewage, careless disposal of garbage, disposal of Ganesh idols and Puja material and poor disposal of construction debris.

Raw Sewage from the neighborhood

A midst the ever increasing urban population the Bangalore Development Authority (BDA) has not established a Sewage Treatment plant (STP). Though plans are underway, the situation currently has experienced release of raw sewage directly to this precious water resource. There is a sewage inlet to the West of the lake that contaminates the water, and thus results in growth of scums of algae at the water surface, that in most cases has resulted in the death of fish by depriving it oxygen.

Fig 4.1 showing untreated sewage released to ullal lake

Careless Garbage disposal

Garbage plays a big role in pollution of Ullal Lake. Lots of eateries are being disposed carelessly in any available pits. The big population in the surrounding quickly dumps the garbage in the landfills which are transported to the lake directly during rainy season. Some dispose the garbage directly in the stream flowing to the lake.

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Fig 4.2 showing garbage disposal at river banks


Fig 4.3 showing Ganesh and puja materials

Ganesh Idols and Puja materials

Lake water of the study area is polluted by human activities due to rituals practiced during Ganesha festival where colored idols are immersed with painted idols and decorative materials. Research has shown that such materials influence the turbidity of the PH, hardness, turbidity, temperature and conductivity. Ganesha idols and Puja materials are quite evident at Ullal Lake.


Fig 4.4 showing overview of Ullal lake

Construction debris and illegal sand harvesting

As the population of the catchment area and surrounding area of the lake increase, there is increasing need for establishment of new houses continuously. This has resulted in debris that has been transported by precipitation to the lake. This has led to siltation making the lake shallow and a possible threat to flora and fauna in the lake. There has been illegal sand mining too at the catchment of the lake also referred to as mud lifting.

Population pressure

The potential of land degradation is usually high in areas with dense population due to human influences. Rising population mounts the pressures on forests, increase in built up areas, reducing range lands and widening marginal agricultural land caused forest removal, land encroachment for urban settlement. Population pressure and economic development prospects are the main drivers of water resource pollution. This has resulted to household pollutants like soaps, detergents, shampoos has led to a phased deterioration of Ullal Lake.

Increase in Built up area

In 1941 the total population of Bangalore was 0.41 million as the City's area covered 29 Square kilometers. When the elections to BBMP was held in the year 2010, its population was 87 lakhs, occupying an area 800 sq Km. It is approximated that the population of Bangalore will be 12.5 million by the year 2020. Lake areas have been diverted for making roads, widening of road. Layouts and apartments are ever extending towards lake boundaries. There are cases of direct link of sewerage lines in to lakes. The areas previously salubrious for their adjacent environment with lakes, have currently become unhygienic because of pollution and bad odor. The lake is surrounded by a heavily built up area constituting of adjacent institutions like Bangalore Jnanabarathi campus, colleges, industries, commercial buildings and ever expanding road network that has increased pressure for pollution.

There has been an upward increase in road network around the lake and a big space has been utilized in road construction clearing up green area. The apartments are built on continuous basis replacing the existing green area accounting to land use change to urban type. Complexes and layouts characterize the surrounding areas. Industries too have been established and temporally Bangalore city continue establishing itself as an industrial powerhouse.

Agricultural and industrial wastes

The North of lake Ullal has coconut plantation; the run-off during the rains carries agricultural waste such as pesticides , fertilizers, plant debris etc. According to a report by Environmental Management & Policy Research Institute, Earlier the coconut plantation at the inlet of the Lake, often brought agricultural waste, such as pesticides, fertilizers, etc. during rains the run off. Prior to the fencing of the lake, trucks and vehicles were washed here. In addition to this, people engaged in washing clothes, cattle and themselves. This eventually adds to pollution of the lake. The lake area was misused as a space for open defecation and garbage dumping leading to the polluted environment with heavy organic load to the lake.

The study interviewed a total of 20 respondents from the lake and the catchment has been summarized in the table below. The results revealed that raw sewage release to the lake, garbage disposal and solid waste pollution from surrounding environment is the major causes of the lake degradation heralding negative impact on the environment by accelerating sediment transport into lake Ullal. Interviews analysis showed that population pressure is the main determinant factor for land degradation that has led to pollution of the lake.

Proposed nature-based solutions for conservation and management of Ullal Lake

Protection of the catchment and rejuvenation

Protected areas are key pillars of water management, while leading in biodiversity conservation. Protected areas, which is well defined geographical space, officially recognized, managed and dedicated, via effective means, to attain long-term management and nature conservation through associated ecosystems and cultural service values. The catchment should be rejuvenated through afforestation program and fining those who abuse the catchments heavily. Area based approaches will take care of the biodiversity prudently. The protected areas should be clearly designated to ensure no ecosystem degradation occurs.

Restoration and creation of green spaces

Restoration is the main strategy to combat ecosystem loss and degradation of the land. This widely depends on the level of ecosystem degradation, political and economic levels. Restoring forests rejuvenates water quality while ensuring a stabilized flow of water and availability. Creating of green spaces in cities can increase revenues for tourism while providing recreational opportunities to the natives. Temperatures will be lowered in urban areas while pollution will be significantly reduced. Vegetation surrounding a lake will help to reduce estuarine erosion as well as filter contaminated water which will encourage thriving of biodiversity.

Sustainable Management of the catchment

Sustainable forest management at the catchments, grasslands,wetlands and mountains, plus agricultural lands, is fundamental for maintaining water services. Key management strategies are: prudent management of vegetation along rivers, riparian zones, at stream and river banks. Practicing sound agricultural management is key, through minimum tillage,cover crops, the use of strips of natural vegetation in farms, as well as decreased use of fertilizer and pesticides.Keeping the right number of cattle in a farm too comes in handy.

Buffer zone vegetation and riparian protection and mitigation

Clearance of riparian and buffer zone vegetation should be prohibited.The impacts of pollution at the buffer zones should be mitigated by the policy makers and land use planners at the cities reducing pollution hence rejuvenating Ullal influent river that was destroyed.

MLP and SLP programs to clean the lake

The multilayer perception (MLP) and the Single layer perception have worked out very well. There is need to have a large capacity sewage Treatment Plant that can handle more mega-liters per day (MLD) to curb the ever increasing solid waste and sewage. This will ensure that sewage is treated at the entry before being released to the lake. Untreated sewage is a threat to the flora and fauna in the lake. Clean water will facilitate multiple economic activities and recreation such as boating that will raise income to maintain the lake.

Transfer of water from nearby lakes

The adjacent Malatahalli Lake should allow excess water during monsoon to be pumped to Ullal lake. Water too can be pumped from Kommaghatta Lake, which is 2 km away to Ullal lake. This will boost the volume of water in the lake that has decreased due to siltation and previous activities such as sand harvesting.

Raise awareness, Well-being and public engagement

Awareness of the merits of these solutions will aid in guarding the biodiversity,climate and human health and social cohesion.Forests play a crucial role in providing medicines, pharmaceutical products that strongly promote human-well being. Collaboration comes in handy to achieve these.Solutions towards generation of degradable puja materials and ganesh idols should be welcome to consider environmental conservation and eradicate pollution.

V. RECOMMENDATIONS

Use of incentives to encourage environmental conservation should be widely adopted in the catchments, to motivate residents to take care of the catchment. The incentives should be utilized areas of land management especially at the forests and wetlands that are in danger of rapid encroachment to be substituted by urbanization. Village watershed committees should be formed , to act as mediators of key information among the local communities at panchayat level and stakeholders. This will increase more participation and ownership of conservation by the members of the welfare and residents at the catchment areas. Budget should be allocated for environmental conservation and management activities targeting to address land degradation, water and soil conservation. The Bangalore Development Authority (BDA) and BBMP should reach a consensus on who should manage Ullal lake for conveniences in future.

VI. CONCLUSION

The big picture of hope is the reforms that have heralded establishment of key policy framework and formation of institutions such as BDA and BBMP. The institutional framework provides a ground for formation and coordination of strategies for the catchment management. The exchange of information and coordination is mainly done at the top levels. The bottlenecks of fruitful implementation of policy framework and land conservation and management practices are still many. Issues here include rapid urbanization and ignorance by the public on

solid waste disposal. Decision making and implementation of watershed management is still a challenge. More need to be done on policy formulation and implementation to curb pollution that remains a big threat to Ullal Lake and other watersheds that are fast diminishing.

Conflict of interest

The author declares no conflict of interest whatsoever regarding the publication of this paper.

REFERENCES

[1]. Bellamy. J, Ross. H, Ewing. S and Meppem. T, 2002. Integrated Catchment Management: Learning from the Australian Experience for the Murray-Darling Basin. CSIRO Sustainable Ecosystems, Brisbane.
[2]. Bfunkerhoff. D. W, 1996. Coordination Issues in Policy Implementation Networks: An Illustration from Madagascar's Environmental Action Plan. World Development, Vol. 24, No. 9, pp. 1497-1510.
[3]. Budumuru .Y and Tesfa. G. G, 2006. Participatory watershed management for sustainable rural livelihoods in India.
[4]. Burton. J, 2001. Integrated water resource management on a basin level. UNESCO,) Manuel de formation, Institut de l'énergie et de l'environnement pour la Francophonie (IEPF).
[5]. Conley, A. and Moote M. A., 2003. "Evaluating Collaborative Natural Resource
[6]. Management." Society and Natural Resources 16: 371-386.
[7]. Farrington. J and Lobo. C, 1997. Scaling up participatory watershed development in India. Lessons from Indo-German watershed development programme. ODI Natural Resource Perspectives Number 17.
[8]. GEF, 2006. Removing barriers to sustainable land management. Global action on sustainable land management. Global Environment Facility 1818 H Street NW Washington DC 20433 USA.
[9]. GEO-3, 2002. Past, present and future perspectives, UNEP, Earthscan publications Ltd, 120 Pentonville road, London-UK.
[10]. GWP, 2008. Foreword: Participation in water management. Lessons from water.
[11]. Management planning in Africa. Planning for a water secure future.
[12]. GWP, 2007. Toolbox for Integrated Water Resources Management. Stockholm, Sweden. http://www.gwptoolbox.org/.
[13]. ICRAF, 2000. Improved Land Management in the Lake Victoria Basin: Linking Land
[14]. Lake, Research & Extension, and Catchment & Lake Basin. First Report of Progress and Results, July 1999 to March 2000. Nairobi: ICRAF and Ministry of Agriculture and Rural Development.
[15]. Leach. W. D, Pelkey. N. W and Sabatier. P. A, 2002. Stakeholder Partnerships as Collaborative Policy making: Evaluation Criteria Applied to Watershed Management in California and Washington. Journal of Policy Analysis and Management, Vol. 21, No. 4, 645–670.
[16]. Makalle. M. Obando. J and Bamutaze. Y, 2007. A Framework for Integrated Management of Transboundary Basins: The case of Sio sub-catchment in East Africa. Catchment and Lake Research.
[17]. NEMA, 2001. State of environment report, 2000 – 2001. Ministry of Water, Lands and Environment, Uganda government.
[18]. Perez. C and Tschinkel. H, 2003. Improving watershed management in developing countries: A framework for prioritizing sites and practices. Agricultural Research & Extension Network. Network Paper No. 129.
[19]. Sharma. P. N, 1999. Participatory processes for integrated watershed management. Participatory Watershed Management Training in Asia (PWMTA) and Farmer-centred Agricultural Resource Management (FARM) Programs, Netherlands/UNDP/FAO, GCP/RAS/161/NET - RAS/93/062.
[20]. UNCED. 1992. Report of the United Nations Conference on environment and development.Ro declaration on environment and development.
[21]. http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm (accessed May 29 2009).
[22]. Wani, S. P., Singh, H.P., Sreedevi, T.K., Pathak, P., Rego, T.J., Shiferaw, B., and Iyer, S.R, 2005. Farmer-Participatory Integrated watershed Management: Adarsha Watershed, Kothapally India. An Innovative and Upscalable Approach". case 7 in part 3 case example series, ICRISAT, India.